

Portfolio Optimization of Indian Equities Using the Markowitz Efficient Frontier

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Executive Summary

This report presents a quantitative portfolio optimization strategy applied to a set of ten Indian large-cap stocks, using the foundational principles of Modern Portfolio Theory (MPT). By combining historical return analysis, risk estimation, and simulation of thousands of portfolios, the study identifies an optimal allocation that maximizes the Sharpe ratio while maintaining reasonable risk exposure. The project also benchmarks this optimized portfolio against an equally weighted naive strategy to highlight the advantage of systematic diversification.

Objective

To optimize a portfolio composed of selected Indian equities by:

- Simulating 100,000 random portfolios using historical return data
- Calculating and plotting the Efficient Frontier
- Identifying the maximum Sharpe ratio portfolio
- Comparing performance against an equal-weight portfolio

Asset Universe & Data Sources

Selected Stocks: TCS, HDFC Bank, Reliance, ITC, Tata Steel, Bharti Airtel, Asian Paints, Maruti Suzuki, Infosys, Titan.

Rationale: Sectoral diversification, high liquidity and relevance in Indian equity markets, readily available historical data.

Data Period: January 1, 2019 ? December 31, 2024

Source: Yahoo Finance API via yfinance library (auto-adjusted prices used)

Methodology

Step 1: Data Cleaning and Returns Calculation

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- Adjusted daily close prices were cleaned using `.dropna()`.
- Daily returns were computed and annualized using 252 trading days.
- Covariance matrix was computed and scaled.

Step 2: Monte Carlo Simulation ? 100,000 Portfolios

- Randomly simulated portfolio weights
- Calculated return, volatility, Sharpe ratio for each

Step 3: Efficient Frontier Plot

- Scatter plot with color gradient based on Sharpe ratio
- Demonstrates the upper boundary of efficient portfolios

Step 4: Optimization with PyPortfolioOpt

- Used `EfficientFrontier` to maximize Sharpe ratio
- Cleaned weights and evaluated performance

Step 5: Equal Weight Portfolio (Benchmark)

- Compared against a naive 10% allocation strategy

Figure 1: Efficient Frontier (1 Million Portfolios)

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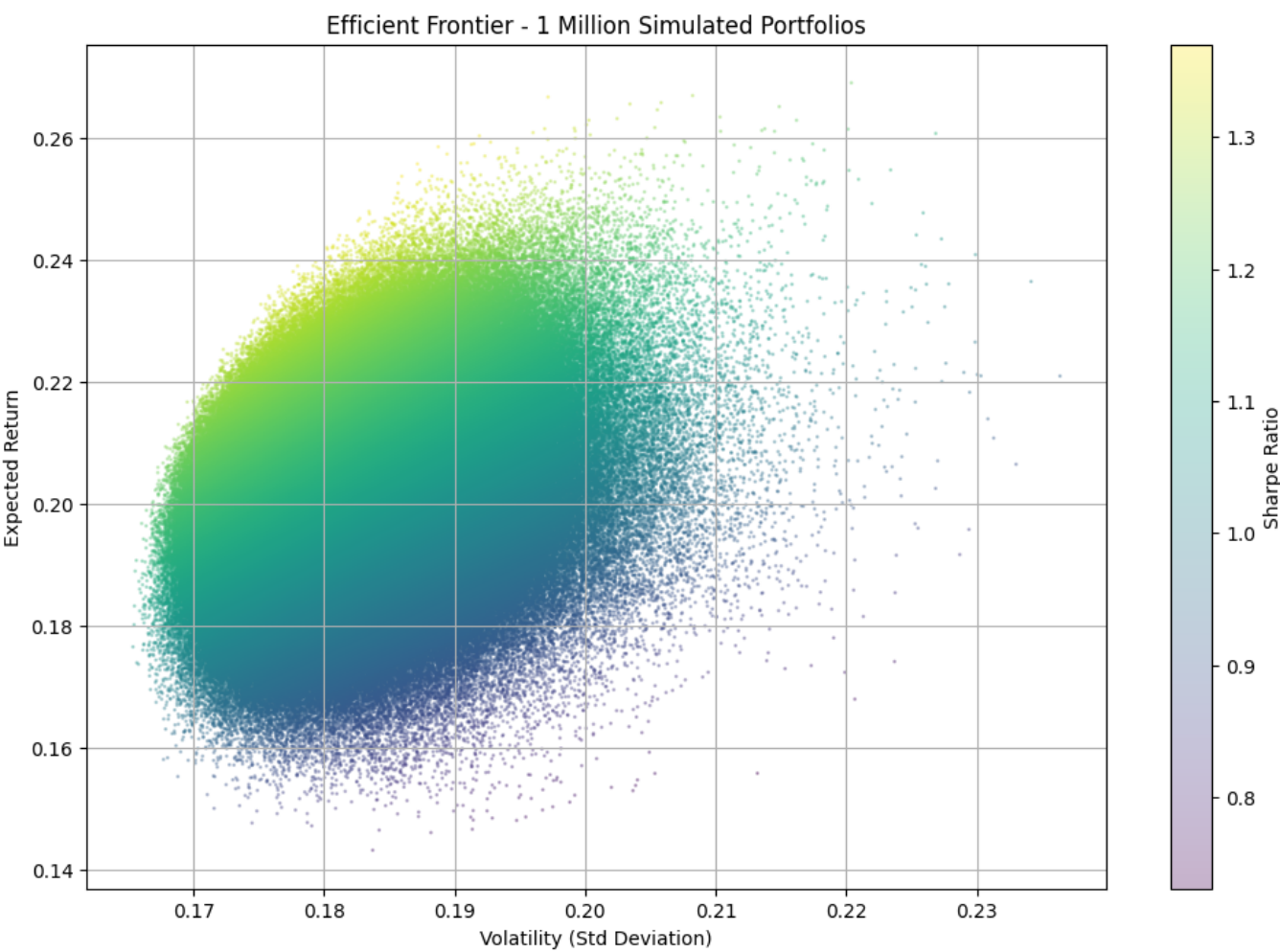


Figure 2: Efficient Frontier (100,000 Portfolios)

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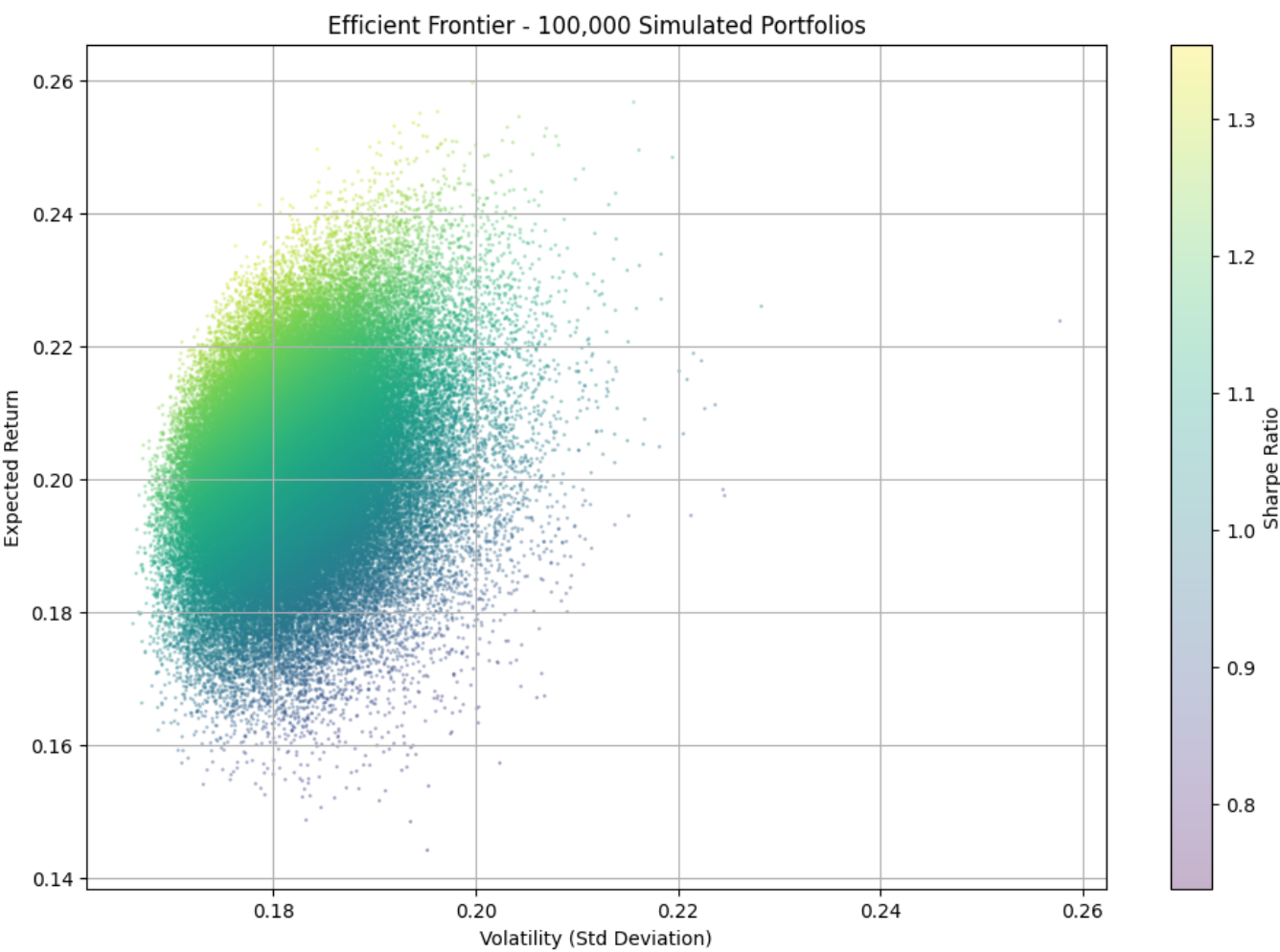
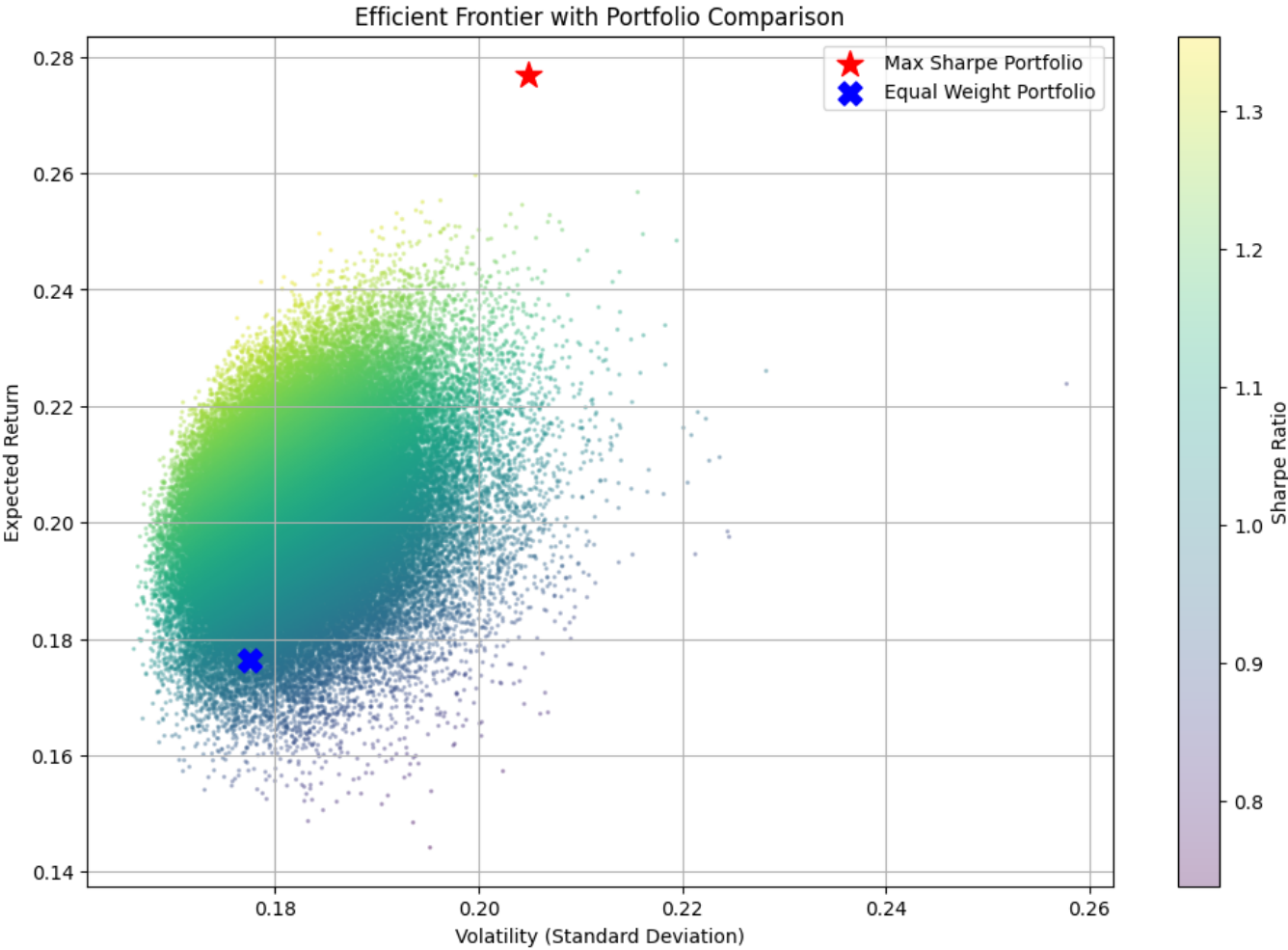


Figure 3: Efficient Frontier with Portfolio Comparison

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Optimized Portfolio (Max Sharpe)

Weights:

- Bharti Airtel: 45.3%
- Titan: 24.3%
- Infosys: 22.8%
- ITC: 4.2%
- TCS: 3.4%
- Others: 0%

Performance:

- Expected Return: 27.7%
- Volatility: 20.5%
- Sharpe Ratio: 1.35

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Equal Weighted Portfolio (Benchmark)

- Expected Return: 17.64%
- Volatility: 17.75%
- Sharpe Ratio: 0.99

Conclusion

This analysis shows that systematic portfolio optimization delivers significantly higher returns compared to equal weighting, with only marginally higher volatility. By leveraging historical data and the principles of Modern Portfolio Theory, investors can construct portfolios with better risk-adjusted returns. Future improvements could include transaction cost modeling, backtesting, and ESG filtering.